A PRELIMINARY SURVEY ON FRESHWATER ALGAL FLORA OF GARUDA TAL, NEAR NAINITAL, UTTARANCHAL, INDIA[1]

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Garuda Tal (lake) is located 23 km from Nainital town of Uttaranchal state in Kumaon division, and situated in the foothills of the Himalaya, at an altitude of 1450 m above msl. An assessment of the diversity of freshwater algal flora of Garuda Tal resulted in a total of 19 species, representing 15 genera of which 3 species were Blue-green Algae (Cyanophyceae), 5 species were Green Algae (Chlorophyceae), and 11 were Diatoms (Bacillariophyceae). *Rhizoclonium, Spirogyra* and *Gomphonema* were abundant in this lake. A preliminary survey and morpho-taxonomic details of freshwater algal flora of Garuda Tal has been described in the present communication.

Key words: freshwater algal flora, diversity, Garuda Tal

INTRODUCTION

Nainital district (29° 24' N and 79° 28' E; area 11.73 sq. km) of Uttaranchal lies in the Kumaon division abutting Himalayan ranges to its north, at an altitude of 1938 m above msl. This area is highly mountainous marked with rugged topography, comprising of high ranges, steep hills, deep valleys, cliffs and sloping meadows. Gola and Kosi rivers flow through this region along with a number of small streams and lakes. The present contribution is the result of preliminary studies carried out on the freshwater algal flora of Garuda Tal, a serene lake.

Garuda Tal is situated 23 km from Nainital town at an altitude of 1450 m above msl. The lake is about 745 m long, 300 m broad and 19 m deep (Das 2003) and lies at the foothills of Western Himalaya. This serene lake is not disturbed by anthropogenic activities; its lush green water is surrounded by thick, tall pine, oak trees along with several herbs and shrubs. The soil of this hilly region varies from loamy to clay loamy. The climate is tropical with cool summers and extremely cold winters. The atmospheric temperature varies from 3-16 °C in winter and 10-28 °C in summer; the average rainfall is 260 cm (National Information Centre, Dehradun, 2000-2005). The temperature of the water varied from 14-16 °C and the pH was 5.5 during the study period.

MATERIAL AND METHODS

A total of 14 freshwater algal samples were collected during May 2002 from Garuda Tal with the help of a simple sample collecting spoon with a long handle. Epilithic algal samples were collected by scraping submerged rocks. Some of the samples were collected by hand squeezing the aquatic plants of the lake. Samples stored in 50 ml sample bottles were preserved in 4% formalin and deposited in the collections of the Phycology laboratory, National Botanical Research Institute, Lucknow. The samples were observed under an Olympus light microscope and camera lucida diagrams were drawn. For diatoms, permanent slides were prepared as per Patrick and Reimer (1966). Taxonomic identification was done as per Desikachary (1959), Jeffery *et al.* (1983), Noda and Lorin (1985), Prasad and Srivastava (1992), Prescott (1951), and Tzanou and Economou (1995).

RESULTS

Among the freshwater algal flora, green algae, blue-green algae and diatoms were identified and their taxonomic descriptions are given below:

Cyanophyceae

Chroococcus minutus (Kuetz) Naegeli (Fig. 2)

A small amorphous, mucilaginous mass in which spherical or hemispherical cells are compactly arranged within a wide hyaline envelope, individual cell sheaths indistinct not lamellate, cell contents blue green, either homogenous or finely granular, cells 5-10 µm in diameter.

Gloeothece samoensis Wille (Fig. 3)

Cells ellipsoidal, without sheath 4-5 µm broad, 8 µm long, cells yellowish or bluish green, in round colonies, mostly 2-4 in a common envelope, envelope colourless.

Oscillatoria nigra Vaucher (Fig. 1)

Trichomes aggregated to form a thick, mucilaginous blackish green mass on submerged objects, becomes free floating, straight or slightly tapering towards the apex and curved, apical cell rotund not capitate without calyptra; cells

8-10 µm in diameter, 4.5 µm long, not constricted at the cross walls, which are sometimes granular, cell content dark olive green.

Chlorophyceae

Rhizoclonium hookeri Kuetzing (Fig. 8)

Filaments crisp, freely branching, composed of long, cylindrical or regularly inflated cells, cell 68 µm in diameter, 380 µm long. An epilithic alga found attached to submerged rocks. *Licmophora flabellata* is an epiphyte on its filament.

Bulbochaete dispar Wittrock (Fig. 10)

Branched filament arising from a basal cell, which has a holdfast organ. Cells cylindrical, ovoid, having successive divisions at the basal cell only, bearing a long seta with a bulbous base. Vegetative cells 35 µm in diameter, 30-40 µm long.

Closterium pseudodianae Roy, West & West **var.** ***curvata*** Kant & Gupta (Fig. 9)

Cells much longer than the type, curved at both the ends, sickle shaped, chloroplast divided into two halves, end pointed or rounded, cells 440-450 µm long, 50 µm in diameter.

Ankistrodesmus falcatus (Corda) Ralfs **var.** ***radiatus*** (Chodat) Lemm. (Fig. 11)

Acicular cells not twisted around each other, arranged in radiating bundles, cells straight or curved, 61-73 µm long, 4.5-5.0 µm in diameter.

Cosmarium medioscrobiculatum West & West **var.** ***egranulatum*** Gutw. f. ***major*** Pandey & Pandey (Fig. 12)

Granules are uniformly distributed and there are no scrobicutations in the centre of the semi cells. Cells 50 µm broad, 90 µm long, and isthmus 32 µm wide.

Spirogyra **sp.** (Fig. 4)

Vegetative cells 260 µm long, 38 µm in diameter with plane end walls, chloroplast 2-3 making 2.5-3 turns.

Spirogyra **sp.** (Fig. 5)

Vegetative cells 200 µm long, 22 µm in diameter with plane end walls, chloroplast 1 making 4 turns.

Spirogyra **sp.** (Fig. 6)

Vegetative cells 210 µm long, 34 µm in diameter with plane end walls, chloroplast 1 making 3 turns.

Spirogyra **sp.** (Fig. 7)

Vegetative cells 240 µm long, 72 µm in diameter with plane end walls, chloroplast 3 making 3 turns.

Bacillariophyceae

Cocconeis pseudomarginata Gregory (Fig. 22)

Rapheless valves with lanceolate sternum and two zones of striae separated by longitudinal hyaline area. Valves 52 µm long, 35 µm wide with delicate radiate striae, marginal striae 13 in 10 µm, axial striae 16 in 10 µm. Raphe with polar nodule small extending downwards into an arrow shaped hyaline area.

Cocconeis diruptagreg **var.** ***flexella*** (Janish & Rabenhorst) Grunow (Fig. 23)

Differentiated from the nominate variety by the sigmoid axial of the rapheless valve. Valves 40 µm long, 24 µm wide with 19-20 striae in 10 µm, in the rapheless valve.

Cymbella tumida (Breb.) Vanheurck (Fig. 14)

Valves asymmetrical, curved, broadly naviculoid with rostrate poles, convex dorsal side and straight or slightly convex ventral sides having medium expansion, raphe eccentric, axial area narrow, central area large, round with a ventrally placed prominent isolated dot, transverse striation radiate, punctate, cells 18-20 µm in diameter, 52 µm in length, striae 10 in 10 µm.

Cymbella ventricosa Kuetzing (Fig. 13)

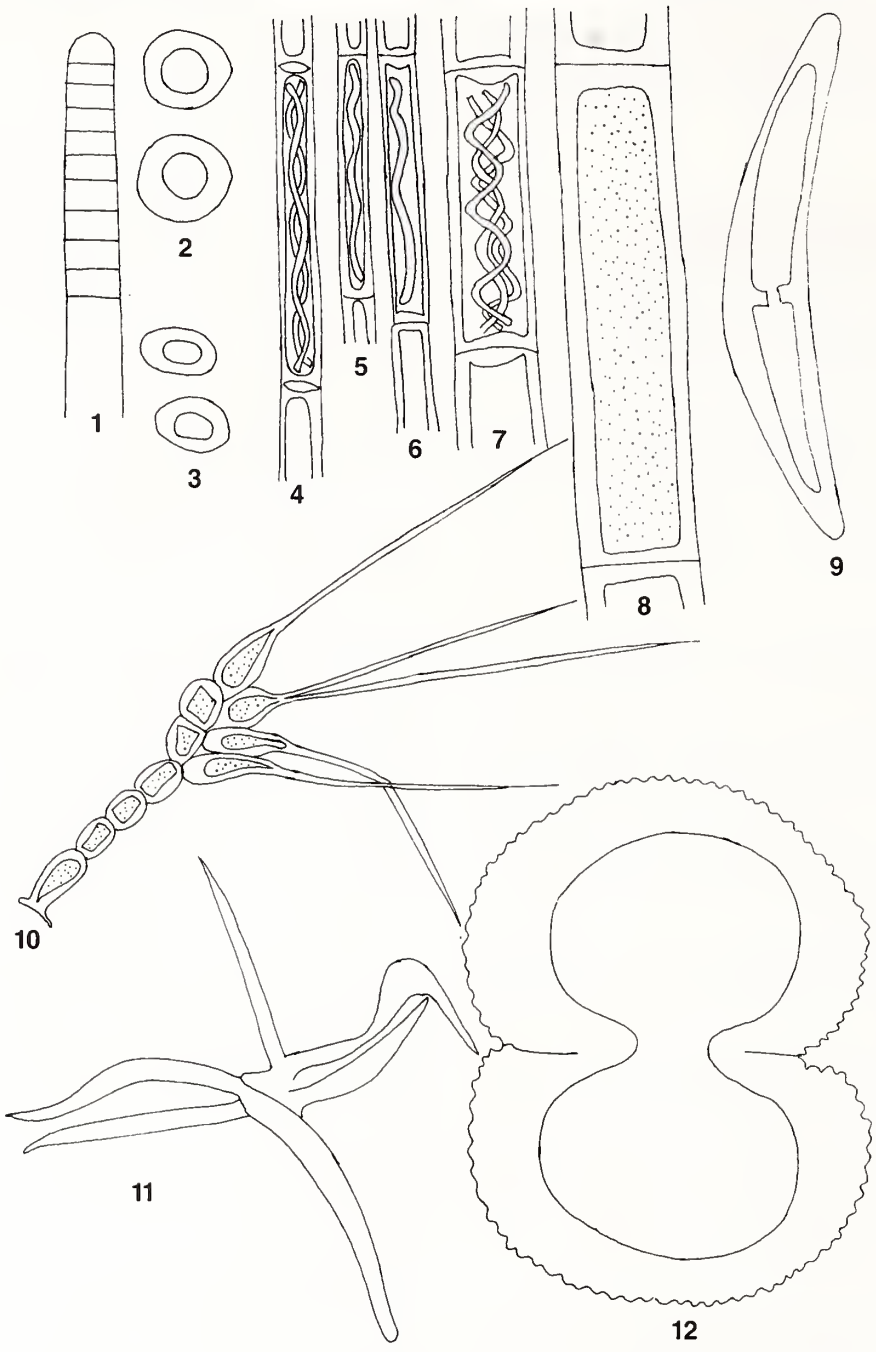
Valves asymmetrical, lunate with dorsal margin convex and ventral margin almost straight, ends acutely rounded, raphe thick, eccentric, slightly undulate, central nodules bent dorsally, while terminal fissure curved ventrally forming a question mark, axial area narrow, linear central area broad, striae coarse, lineate radiate throughout the wall, cells 18 µm in diameter, 65 µm in length, striae 10-11 in 10 µm.

Amphora veneta Kuetzing (Fig. 19)

Frustules oblong, elliptical with truncated rounded ends, in valve view, linear lunate with constricted, ventrally bent, obtusely rounded ends, dorsal side convex but ventral side somewhat concave, raphe thin, straight, eccentric, terminal fissure bent ventrally, axial area narrow, linear, striae lineate, radiate throughout, present on dorsal side. It is 30 µm long, 10 µm broad, striae 15 in 10 µm.

Amphora coffeaeformis Agardh (Fig. 20)

Valves linear, semi-lanceolate with constricted much produced rounded ends, dorsal margin broadly arcuate, ventral margin straight or concave, raphe thin eccentric, slightly undulate, central nodule bent dorsally, axial narrow, gradually widening towards centre, dorsal striae coarse



Figs 1-12: 1. *Oscillatoria nigra* 10 x 40; 2. *Chroococcus minutus* 10 x 40; 3. *Gloeothece samoensis* 10 x 40; 4. *Spirogyra* sp. 10 x 10; 5. *Spirogyra* sp 10 x 10; 6. *Spirogyra* sp 10 x 10; 7. *Spirogyra* sp. 10 x 10; 8. *Rhizoclonium hookeri* 10 x 10; 9. *Closterium pseudodianae* var *curvata* 10 x 10; 10. *Bulbochaete dispar* 10 x 10; 11. *Ankistrodesmus falcatus* var *radiatus* 10 x 40; 12. *Cosmarium medioscrobiculatum* var *egranulatum* f. *major* 10 x 40

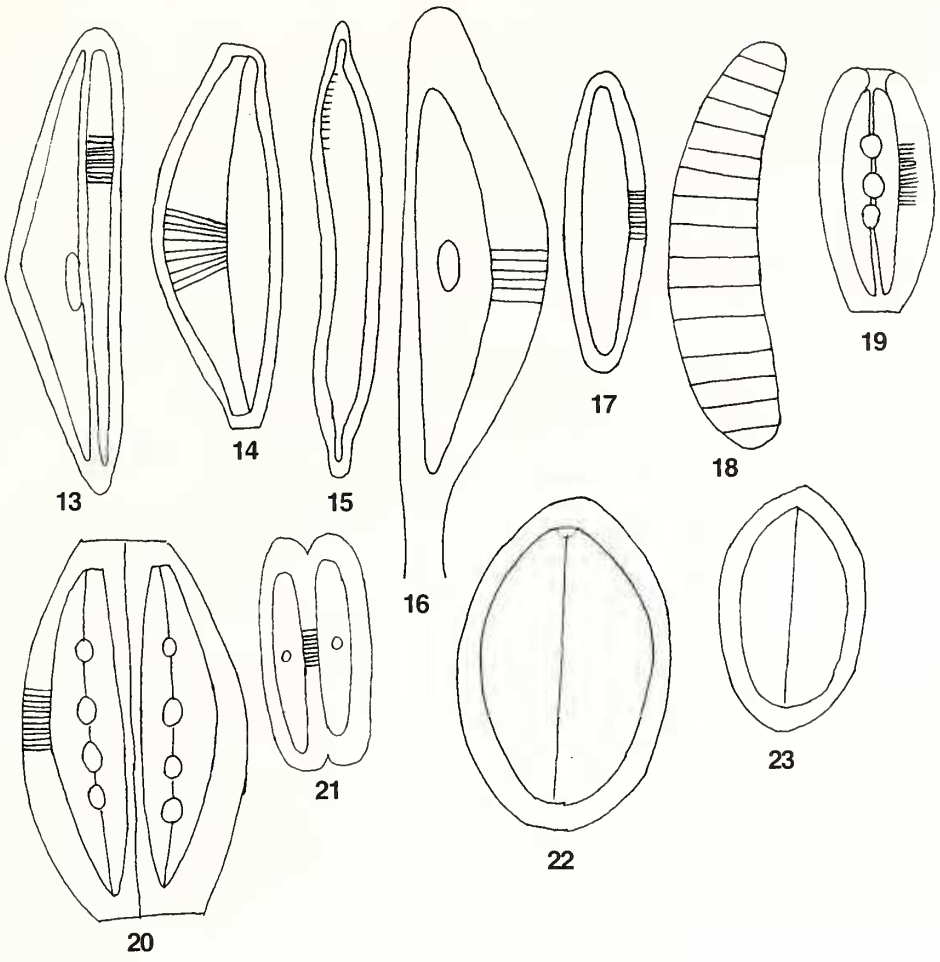
lineate, radiate, parallel throughout the valve, ventral striae very short, fine and close. It is 53 µm long, 20 µm broad, dorsal striae 11-13 in 10 µm, and ventral striae 20-22 in 10 µm.

Amphora clevei Grun. (Fig. 21)

Frustules crescent shaped in valve view, broadly elliptic with truncated poles in girdle view, raphe presents two curved lines near the ventral margin of the valve and the two curves meeting over the central nodule, valves 30 µm long, 15 µm in diameter.

Epithemia argus (Ehr) Kuetzing (Fig. 18)

Frustules solitary or in a group, valve arcuate, dorsal side convex and ventral planoconvex, ends rounded, raphe



Figs 13-23: 13. *Cymbella ventricosa* 10 x 40; 14. *Cymbella tumida* 10 x 40; 15. *Hantzschia amfioxys* 10 x 40; 16. *Gomphonema hebridense* 10 x 40; 17. *Gomphonema constrictum* 10 x 40; 18. *Epithemia argus* 10 x 40; 19. *Amphora veneta* 10 x 40; 20. *Amphora coffeaeformis* 10 x 40; 21. *Amphora clevei* 10 x 40; 22. *Cocconeis pseudomarginata* 10 x 40; 23. *Cocconeis dirupta* var *flexella* 10 x 40.

curved, V-shaped on the ventral side. Cells 62 µm long, 12 µm in diameter, costae 3 in 10 µm.

Hantzschia amfioxys (Ehr.) Grunow (Fig. 15)

Valves narrowly linear, lanceolate, dorsal side convex, ventral side slightly concave, with deep median depression, ends slightly attenuated, constricted, rounded capitate, keel punctae distinct thick slightly elongated, medium two set apart, central nodule prominent, striae fine, lineate, parallel throughout the valve. It is 74 µm long, 7 µm broad, striae 18-25 in 10 µm.

Gomphonema constrictum Ehr. (Fig. 17)

Valves broadly clavate, broadly rounded, apex not very large, central area defined with more isolated punctae, raphe thick and straight, striae alternately long and short, valves 45 µm long, 12 µm in diameter, striae 10-12 in 10 µm.

Gomphonema hebridense (Greg.) Her. (Fig. 16)

Valves broadly clavate, axial area not very large, central area defined, median striae not alternately long and short, valves very slender and central area very small. Valves 5 µm in diameter, striae 6 in 10 µm.

DISCUSSION

The present study documents nineteen taxa of high mountainous freshwater algal flora of Garuda Tal. Cyanophyceae was represented by three genera and three species, Chlorophyceae by six genera and five species, Bacillariophyceae by six genera and eleven species; *Rhizoclonium*, *Spirogyra* and *Gomphonema* were abundant, whereas *Oscillatoria*, *Chroococcus*, *Cocconeis* and *Cymbella* were common. Kant and Gupta (1998) have also given detailed taxonomic enumeration of freshwater algae like

Oscillatoria, *Chroococcus*, *Spirogyra*, *Cymbella*, *Gomphonema* and *Cocconeis* from the ponds and streams of Ladakh, Kashmir. Sahin (2003) reported *Cymbella*, *Fragillaria*, *Pinnularia* and *Surirella* as common diatoms, *Oscillatoria* was the common blue-green alga and desmids were the common green algae from the mountain lakes of Eastern Black Sea region, Turkey. Diatoms were numerous in both the Garuda Tal and lakes of Eastern Black Sea. The results obtained from Garuda Tal are similar to the data of Sahin (2003) from the Eastern Black Sea.

Medvedeva (2001) recorded Cyanophyta, Chlorophyta, Bacillariophyta and few taxa of Chrysophyta, Dinophyta and Xanthophyta from temperate benthic communities in Sikhote Alin biosphere reserve in Russia. These forms were also reported by Tolotti (2001) from Adamello Brenta Regional Park in Italy and by Banderas-Tarabay (1997) from lake E Isol in Mexico. We did not encounter algal forms belonging to Chrysophyta, Dinophyta and Xanthophyta from Garuda Tal.

Ever increasing population, agricultural activities and industrial pollution are the main threats to our environment. Garuda Tal is an ideal example of a natural system and it is largely ecologically intact and remote from industrial and agricultural centres of this region. Therefore, algal assemblage of this lake can be of great value in providing base line data for future monitoring and assessing the effects of anthropogenic activities.

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